Jungle Rubber: a traditional agroforestry system under pressure

L. Joshi, G. Wibawa, G. Vincent, D. Boutin, R. Akiefnawati, G. Manurung, M. van Noordwijk and S. Williams
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The following are the highlights from the self-help group initiative implemented in the three villages in Jambi:

1. Farmers understood the value of incorporating high yielding planting material into their jungle rubber agroforestry system, and made efforts to do this.

2. Visits to research and demonstration plots significantly enhanced farmers' confidence in, and awareness of, available technology and developments.

3. Farmers were keen to acquire, and adept at learning, skills necessary for local production of high yielding clonal material.

4. Farmers were capable, following a brief training session, of carrying out direct grafting of rubber.

5. It was possible to mobilise farmer self-help groups to establish and manage budwood gardens for clonal bud and plant production. However, this required intensive social mobilisation.

6. Homogeneity among group members, inter-personal relationships and committed leadership were important driving forces that influenced the level of success achieved in three villages.

7. Communication and visits between farmer groups have the potential to augment farmer interest by sharing knowledge and developing positive competition between groups.

Figure 36. Some members of a village nursery group pose proudly for a group photograph in front of their nursery (Photo: Ratna A Kisthawati).
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L Joshi1,2, G Wibawa3, G Vincent1,4, D Boutin1,5, R Akiefnawati1, G Manurung1, M van Noordwijk1 and S Williams6

1. ICRAF SEA
2. University of Wales, Bangor (UK)
3. Indonesian Rubber Research Institute
4. IRD (France)
5. CIRED (France)
6. Freelance Consultant

ICRAF - World Agroforestry Centre
Transforming Lives and Landscapes
8.3 Environmental services of jungle rubber agroforests

In the context of the disappearance of natural forests, complex agroforests, such as jungle rubber agroforests, can provide external environmental services as well as meeting local production functions. These environmental services include sequestering carbon from the atmosphere, maintaining biodiversity and retaining hydrological functions. Farmers and communities, who protect and maintain forests and complex agroforests, are not normally compensated for the provision of environmental services. Compared with more intensive monoculture plantations, and with other land-use systems, complex agroforests, such as jungle rubber agroforests, are less profitable and are currently being challenged by alternative land-use options. In the absence of incentives, farmers often opt for land use forms that provide fewer of the environmental services which are essential for external stakeholders and which often extend far beyond village, provincial and national boundaries.

Among research, development and donor communities, there is growing awareness of, and interest in that efficient payment transfer schemes, that (if implemented efficiently and fairly through appropriately-developed mechanisms) could help to preserve complex agroforests and the environmental services they provide. ICRAF has recently initiated research to quantify these environmental services, to develop methods to monitor them, and to evaluate the economic benefits of various land-use options. Farmers practising jungle rubber agroforestry are possible candidates for reward because of the biodiversity services their agroforests provide. In an institutional context, it is essential that both environmental service providers and beneficiaries of the services can freely negotiate and develop mutual agreements. Appropriate policy environments need to be developed, through appropriate negotiation and dialogue, in order to develop and nurture such reward mechanisms. All stakeholders (i.e. farmers, farmer groups, village organizations, local government, researchers, development professionals, non-governmental organizations, and donors) have important roles to play in this process.

References

the fact that rubber timber needs to be processed within 72 hours of felling, are major constraints to rubber-wood harvesting and marketing. Consequently, farmers almost always burn old rubber trees, which are seen as being, essentially, a by-product of jungle rubber agroforests. Valuable natural resources are wasted (Figure 37), while the hazards posed by fire and smoke remain unresolved. Policy amendments, to encourage trade in rubber timber and non-rubber timber taken from rubber based agroforestry systems, will not only increase the appropriate use of timber from agroforests, but will also improve household incomes and promote polyculture in rubber-based agroforests while reducing farmers’ dependency on a single commodity - latex. It will also reduce demand for other timbers extracted from natural forests, as well as diminishing the hazard posed by smoke and fire, and will cut greenhouse gas emissions. Procedures to properly identify timber extracted from agroforests, and to promote trade and processing of that extracted timber (Figure 38) need to be developed through targeted policy research and subsequent improvements in policy.

### Preface

The International Centre for Research in Agroforestry (ICRAF) began research into rubber based agroforestry systems (*Hevea brasiliensis*) in the Jambi Province of Sumatra (Indonesia) some seven years ago. Various research activities, including surveys and experiments, have been undertaken since then. This booklet contains some of the research findings which were the result of these activities. These findings concern various issues associated with jungle rubber agroforestry, which are specifically relevant to the context of Jambi Province. The booklet has eight sections, each covering different aspects of the system. These are summarised in the following diagram.

Section 1 of this booklet contains information about the beginning of 'Para' rubber (*Hevea brasiliensis*) cultivation in Jambi Province, a process which quickly transformed the landscape of the region. This brief history is followed, in Section 2, by an account of the various forms of jungle rubber which now exist. The socio-economic issues influencing farmers’ decisions when they choose between slash and burn and a more permanent system of agroforestry are discussed in Section 3. The local
ecological knowledge of farmers is considered in Section 4. Section 5 summarises current scientific understanding of the growth and productivity of jungle rubber agroforests. Section 6 includes brief summaries of relevant experiments carried out in order to develop improvement pathways for jungle rubber. The testing of farmer institutions as a means to garner support and required resources to improve the system in a collective manner is described in Section 7. Finally, Section 8 considers some policy issues that impinge on the production of, and even threaten the existence of jungle rubber agroforestry as a viable option for smallholder farmers in Jambi Province. Examples of real life cases are provided in boxed texts to highlight a number of important aspects of jungle rubber.

The information in this booklet has been compiled from numerous research activities and surveys carried out in Jambi. However, this is not a comprehensive report on such research, nor does this booklet report the findings of all research undertaken by the many institutions active in the Province. The support, both financial and otherwise, provided by Department for International Development (DFID, UK), the University of Wales, Bangor (UK), Institut de Recherche pour le Développement (IRD, France), Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD, France) and the Indonesian Rubber Research Institute (IRRI), Sembawa Research Station (Palembang, Indonesia), for various projects and activities, has been instrumental to our research in jungle rubber. However, these institutions, including donor organisations, are not responsible for the information contained in this booklet.

and lower levels of fertilizer. However, the regeneration of significant biodiversity values is far less than is the case in jungle rubber agroforests. Interestingly, current low rubber prices stimulate the development of sispian style management of 'other tree' components of the system (for example, timber species). However, both the current price of natural rubber (the lowest in the last three decades) and the recently introduced Indonesian National Standard (SNI) regulations (Wibawa et al., 2001) have jointly affected many resource poor farmers' income from rubber. The abandonment of old jungle rubber plots, and the conversion of these high biodiversity rubber gardens to oil palm or rubber monoculture, is becoming increasingly common in Jambi.

Despite the prevalence of jungle rubber agroforests in Jambi, and in many other rubber growing provinces in Indonesia, only meagre efforts have been made to develop them for higher productivity while maintaining the comparative advantages, such as biodiversity maintenance and management flexibility, they offer. All past rubber development projects have been largely geared to replacing these complex, flexible, low-input, yet diverse and less risky, systems with monocropping systems. The history of rubber development shows that most, if not all, rubber research and developments have favoured capital intensive and labour saving technologies that are less appropriate for capital-limited rubber farmers (Barlow et al., 1994). It is time the Indonesian government and national institutions realized the value and importance of jungle rubber agroforests, not only for rubber producing households but also for their regional and global environmental services (Section 8.3). Recognition of the existence of extensive jungle rubber agroforests and research and development initiatives intended to improve them will be a positive step away from the eradication of these environmentally beneficial land use systems.

8.2 Agroforestry timber deregulation

The extraction and sale of timber, both from natural forests and from agroforests, is restricted in Indonesia by means of taxes, quotas and complex bureaucracy. These regulatory policy mechanisms, coupled with the fact that rubber timber needs to be processed within 72 hours of felling, are major constraints to rubber-wood harvesting and marketing. Consequently, farmers almost always burn old rubber trees, which are seen as being, essentially, a by-product of jungle rubber agroforests.
8. The long time delay (one year of weekly labour contribution involved in establishing and managing the nurseries) before any benefits could be realised was a major reason for a decline in group participation. Involving these groups in other activities, such as the joint marketing of latex, would significantly increase farmers’ interest in such a self-help group approach.

8. Policy considerations

It is estimated that nearly 10% of Jambi Province is under rubber cultivation, most of which is still managed as complex jungle rubber agroforests. Current evidence indicates that around 47% of rubber farmers in Jambi practice ‘sisipan’ (i.e. a gap-level interplanting management style) in at least one of their jungle rubber plots, as an alternative to slash-and-burn rubber agroforestry. However, there is a strong indication that this is a “second best” strategy for farmers, used to address the need for a continuous income, the need for high initial capital investment to restart a new rubber cycle, and to address the issues of increasing scarcity of new land for intensification and the risk of vertebrate pest damage and subsequent crop failure.

8.1 Recognising jungle rubber agroforestry and sisipan as viable management options

An international workshop held in Muara Bungo (September 3 - 6, 2001) carried out a broad systems analysis of the rubber agroforests of Sumatra’s lowland peneplains. The current trajectories, with their consequences for profitability and environmental services, and the options to build on farmers’ ecological knowledge and decision making in new ways, to face the challenges of a changing landscape, were discussed. It is now recognised that jungle rubber agroforests are potentially one of the primary reservoirs of the fast-disappearing biodiversity of the Sumatran peneplains. Plot-level inventories suggest that jungle rubber agroforests can maintain about 50% of the biodiversity found in natural forests.

On-farm Rubber Agroforestry Systems (RAS) trials have proven the feasibility of establishing clonal rubber under less intensive management regimes (when compared with monocrop plantations), using less labour
farmers’ group approach proved less successful than in Lubuk village. Farmer participation at nursery activities and group meetings became progressively more and more difficult. Both groups stopped functioning within about 18 months of coming into existence. These two nurseries were then given up to their respective land owners to be managed as private nurseries.

The following are the highlights from the self-help group initiative implemented in the three villages in Jambi:

1. Farmers understood the value of incorporating high yielding planting material into their jungle rubber agroforestry system, and made efforts to do this.
2. Visits to research and demonstration plots significantly enhanced farmers’ confidence in, and awareness of, available technology and developments.
3. Farmers were keen to acquire, and adept at learning, skills necessary for local production of high yielding clonal material.
4. Farmers were capable, following a brief training session, of carrying out direct grafting of rubber.
5. It was possible to mobilise farmer self-help groups to establish and manage budwood gardens for clonal bud and plant production. However, this required intensive social mobilisation.
6. Homogeneity among group members, inter-personal relationships and committed leadership were important driving forces that influenced the level of success achieved in three villages.
7. Communication and visits between farmer groups have the potential to augment farmer interest by sharing knowledge and developing positive competition between groups.
produce high yielding planting material and grafting material of *Hevea brasiliensis* at low cost and with minimal external support.

The initial stages of group mobilisation and self-help group formation were supported by the ICRAF staff in Muara Bungo. Labour, land and other local resources for the construction and running of the nursery were provided through contribution by group members (Figure 35). Weekly labour was contributed on a voluntary basis (locally called *gotong royong*) by members for routine nursery activities such as seeding, transplanting, watering and weeding. In the first season, ICRAF contributed most of the locally-unavailable input materials, such as mother plants (the source of clonal buds), fertilisers and seed for rootstock. However, subsequently, input material was provided only when requested by the groups, and only when other alternatives were difficult to implement (“drip” support).

The budwood garden in Lubuk village (Figure 36) was the most active and successful in terms of group dynamics and nursery operation. The majority of the members were Javanese migrants, and their positive attitude towards group work has been a crucial factor in the success of their initiative. By mid 2001, each member had received his or her share of more than 60 grafted plants, either rooted or potted. More plants were being distributed later in the year. In Rantau Pandan, Pak Yani, who was a group member and also a school teacher, had established a school nursery which he used for teaching his students. By the end of the first year of establishing the nurseries, a number of farmers in these villages had established their individual “home” nurseries, often just behind their houses. A few farmers had also carried out direct grafting in their recently planted fields with very promising results (grafting success rate between 70 and 90%).

However, as time went on, in Rantau Pandan and Sepunggur villages, the

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1 'Para' rubber in Jambi province

Until the start of the 20th century, Jambi Province in Sumatra (Indonesia) was largely covered by natural forests. It had experienced little economic development, and had a poorly developed infrastructure. Rivers were the main medium of transportation. Most people practiced shifting cultivation and the gathering of forest products, including timber and some latex. However, latex, or 'getah', gained importance towards the turn of the century, when demand from industrialised countries for natural rubber increased and created a ‘rubber boom’. The high price of rubber attracted the attention of farmers and colonial (Dutch) officials, and they began to cultivate latex-producing trees.

The first plantations were established in the 1890s, using the local species *Ficus elastica*. Although 'para' rubber (*Hevea brasiliensis*, from Brazilian Amazon) was by that time already known in Indonesia, *F. elastica* was the preferred species for latex production because it gave higher yields in field trials. However, preference shifted to *Hevea* after the introduction of improved tapping techniques increased its productivity beyond that of *F. elastica*.

In the early twentieth century, ‘para’ rubber was introduced to Sumatra from Peninsular Malaysia by migrant plantation workers, tradesmen and passing pilgrims. Many local farmers from Central Sumatra went to work in new rubber plantations in Malaysia, both to avoid the taxes and forced labour schemes introduced by the recently-established Dutch government in Central Sumatra, and because they were attracted by the high wages offered by the Malaysian plantations. These individuals returned with seeds and seedlings, as well as with the knowledge and skills necessary to grow and tap rubber trees.

Smallholder rubber was first planted in Jambi in 1904. This event was reported in 1918 by an agricultural extension officer, who observed rubber trees that had been planted in slashed and burned fields, but that were managed (or unmanaged) as though ‘wild’, along with other natural vegetation. This was the first recorded incidence of jungle rubber agroforestry in Jambi. Although ‘para’ rubber was a species used primarily by estate plantations in the early years, it was quickly adopted by smallholder farmers who realised that it fitted into their existing practice of shifting cultivation in crop-fallow systems very well. Rice and other

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1 Figure 35. Members of a self-help group in Lubuk village are collecting sand for their group nursery from a nearby river (Photo: Ratna A Kiefnawati).
7. Farmer institutions and capacity building: self-help group approach

In an effort to test participatory research and development in rubber agroforestry in Jambi Province, a pilot initiative for a self-help group approach was implemented in a number of villages. Three villages (Rantau Pandan, Sepunggur and Lubuk) with contrasting backgrounds and characteristics were selected. The following activities were organised to make participants aware of available technology and information relevant for jungle rubber agroforests:

1. farmers’ field visit to ICRAF research sites (RAS experiments and observation plot of direct grafting under sisipan system) (Figure 33);
2. participatory appraisal of current rubber production systems;
3. a half day training course on budwood grafting in rubber seedlings (Figure 34).

Following these activities, farmers formally established self-help groups in all three villages. The common objective of all three groups was to establish local budwood gardens, where farmers could collectively...
Box D.
Pak Irvan's oil palm plantation

Pak Irvan inherited an oil palm plantation from his father, who died 5 months ago. The total plantation area is about 250 ha, including 150 ha under production (yielding 15 tonnes/ha in 2001). The field consists of plantations of three ages (around 12 years old; around 8 years old and around 4.5 years old), all of which have been converted, by means of slash and burn, from old forest (possible secondary forest). In 1992-93, Pak Irvan's father bought 115 ha land from the neighbours and planted oil palm. Currently there are 24 permanent labourers, and 60-80 temporary labourers, working in the field. Recently Pak Irvan sold oil palm fruits (fresh bunches) in the neighbouring Riau Province at Rp 470/kg.

He tried to persuade his neighbours to plant oil palm trees and make arrangements for share tapping, but has not really succeeded in this because his neighbours lack the capital needed for investment. However, two farmers (both of whom are staff members of the government-owned oil palm plantation, PTPN V) have planted oil palm around his field (40 ha by Pak Tampubolon and 20 ha by Pak Susilo).
2. Forms of jungle rubber

Because the term forest is associated with conflicts with the State, farmers prefer to use the term kebun karet (‘rubber garden’) to refer to their agroforests. Many farmers rejuvenate their rubber gardens only after production from the old rubber becomes very low. They do so by slashing and burning to start a new jungle rubber cycle, hence called a cyclical rubber agroforestry system or CRAS, Figures 3, 4 and 5, (Gouyon et al., 1993; Joshi et al., in press [b]). In this process, farmers use either locally-obtained rubber seedlings (the traditional practice) or improved clonal planting material. In the field is technically possible under the light overhead canopy density (Figures 31 and 32), that is commonly encountered in jungle rubber agroforests. Grafting success, and the successive growth of these buds under a light canopy, was comparable to growth in trials undertaken in the open, especially for clone PB 260.

2. However, bud growth is significantly affected by canopy and other competition factors within existing stands; hence direct grafting under a dense canopy is not feasible.

3. Among the two clones tested, PB 260 outperformed RRIC 100. Given that both these clones, as with most other clones in use, have been selected based on their performance in a no-competition environment, testing a wider array of clones for under-canopy grafting may reveal more clones which are potentially suitable for such conditions.

4. Careful overhead canopy manipulation, and a reduction of the effect of ground vegetation on newly grafted plants, will most likely enhance survival and growth of these directly grafted plants.
In summary, the two systems, RAS 1 and RAS 2, are innovative and can be adapted to fit various field conditions and farmer preferences. RAS 1 is a low cost approach. RAS 2, while requiring more investment in capital and labour, may be suitable where agricultural land is becoming scarce or diversification of production is preferred.

6.4 Direct grafting of clonal buds on in-situ seedlings

Latex productivity in jungle rubber agroforests is low and variable, due to the inferior planting material (unselected wildlings) used. While the potential of clonal material in monocrop plantations is well known, clonal material has not been tested by farmers in a sisipan (gap-replanting) context. The general perception of farmers is that clonal material can be feasibly grown only under intensive management. In an experiment carried out by ICRAF, nursery-grafted planting materials of different clones did not perform well when planted inside an existing rubber agroforest. An alternative approach is to graft buds of a high yielding clone directly onto local seedlings (either transplanted or undisturbed) with intact root systems, in the field (Joshi et al., in press [a]). This method can significantly increase the chances that these grafted plants will survive and grow.

It is already known that some farmers in South Sumatra (in Lubuk Bandung) actively practice direct grafting onto seedlings planted in slashed and opened fields (Figure 29). The feasibility of carrying out direct grafting under a sisipan context was successfully tested in a multi-location trial in Jambi Province (Figure 30). Two recommended clones (PB 260 and RRIC 100) were grafted onto existing seedlings under two levels of over-head canopy density and one under no-canopy (open plantation) conditions.

The following conclusions were drawn from the experiment:

1. The grafting of buds of high yielding rubber clones directly onto seedlings in the first few years, smallholder farmers often plant upland food crops such as rice, maize, soybean, mungbean, pineapple or banana. Estates plant leguminous cover crops while the young plants become established.

Many smallholder rubber farmers lack sufficient capital to invest in the slashing, burning and replanting of rubber trees in their old rubber gardens. This lack of capital is not the only obstacle these farmers face: it is compounded by the fact that most of these plots are the major income source for these households, and by a decline in the availability of land for new planting in the area, as well as by the risk of failure due to vertebrate (wild pig and monkey) pest damage. To address these problems, farmers in Jambi have adopted a different technique of rejuvenation, one that does not require slashing and burning. In the sisipan system, new rubber seedlings are planted inside mature rubber gardens, in forest gaps, to replace dead, dying, unproductive or unwanted trees (Figure 6). This technique has the potential to significantly prolong the productive stage of rubber gardens.

Although some farmers perceive the gap replanting strategy as ‘old-fashioned’ and less efficient in terms of production and management, nearly half of rubber farmers actively carry out gap replanting in their rubber gardens. Some farmers in Jambi have practised this management style successfully for decades, although most seem to have started only...
within the last ten years or so. As many farmers own more than one plot of rubber agroforest, they are practising both sisipan and slash and burn simultaneously in different plots. As socio-economic and biophysical factors vary between villages, the proportions of farmers practicing sisipan can be expected to change accordingly.

3. Socio-economic factors and farmer decisions

Research carried out in Jambi, in the Muara Bungo District (in the villages of Rantau Pandan, Sepunggur, Danau and Muara Kuamang) and the Batanghari District (in the villages of Sungai Landai, Suka Damai, Malapar, Napal Sisik, Pelayangan, Rantau Kapas Mudo and Tuo), indicated that about 47% farmers undertake gap replanting in at least one of their rubber gardens (Wibawa et al., 2000b).

Farmers gave five different reasons, in the same survey, for carrying out gap replanting in their old jungle rubber gardens:

1. to maintain continuity of income from their existing gardens (89%);
2. because they lacked capital to slash, burn and replant the plot (70%);
3. because they were unwilling to take the high risk of vertebrate pest damage, especially by wild pigs (63%);
4. they had confidence in gap replanting as a feasible approach to rejuvenate an old rubber garden (59%);
5. gap replanting is less labour-intensive, and may be carried out at times when tapping is not practised (36%).

Farmers following a slash-and-burn approach prior to rubber replanting, perceived that ash from the burned vegetation was necessary for rubber seedling growth (67%), and necessary for the successful growth of other agricultural crops (42%). Of these farmers, 30% said that most rubber trees in their rubber gardens were beyond the productive stage, and stated that these had to be replaced; gap replanting was not seen as a viable strategy under these circumstances. Some farmers were interested in planting clonal rubber or were participants in projects promoting clonal rubber (19%) and, again, did not perceive gap replanting as feasible method of rejuvenating their agroforest. Other reasons given for using the slash-and-burn technique included easier preparation of land for crops and rubber plants, as well as the convenience of guarding against vertebrate pests in open fields.

around the food crops while the associated trees shade out unwanted weeds, particularly after canopy closure. Cash crops have the potential to provide an additional income while rubber trees are being established. Fruit trees, like rambutan (Nephelium lappaceum) and jackfruit (Artocarpus heterophyllus), can add to a household’s income before rubber trees come into production. The mixture of tree and agricultural crops used can be selected based on their value in the region (see example combinations in Figures 26, 27 and 28). Inter-tree competition can be controlled by maintaining an appropriate density of rubber trees and fruit trees.
Trials in Jambi and West Kalimantan confirmed that the less intensive weeding under the RAS 1 system does not affect rubber tree growth (Figure 25). Rubber trees can be tapped five years after planting, just as in intensively-managed estate plantations. Natural vegetation growing more than 1 m away from rubber trees has little effect on their growth. Rubber trees and natural vegetation can actually check the proliferation of unwanted weeds and Imperata (Imperata cylindrica).

Figure 25. Little difference was observed between girths of 4-year old rubber trees under varying weeding intensities in the RAS 1 trials.

6.3.2 RAS 2

In contrast to RAS 1, the RAS 2 approach is more intensive in terms of crop mixtures. The system comprises food crops in the first few years along with rubber trees and other tree crops, such as fruit trees, timber trees and also with medicinal plants. Rubber benefits from weeding

Rubber contributed, on average, 70% of the total household income in the surveyed villages (see Table 1 for details of average household income and expenses). The high dependency of such farmers on revenues from rubber means that those with no alternative source of income are unlikely to use slash-and-burn systems, as income from the replanted plot would stop until the new trees reached the productive stage.

Table 1. Average yearly income and expenses of farmers' households.

<table>
<thead>
<tr>
<th>Details</th>
<th>Total in rupiah ‘000</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources of income</td>
<td></td>
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<tr>
<td>Rubber</td>
<td>4819</td>
<td>69</td>
</tr>
<tr>
<td>Non rubber farming</td>
<td>1424</td>
<td>20</td>
</tr>
<tr>
<td>Off farms</td>
<td>768</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>7011</td>
<td>100</td>
</tr>
<tr>
<td>Expenses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption (mostly food)</td>
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<td>68</td>
</tr>
<tr>
<td>Education</td>
<td>46</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>2028</td>
<td>31</td>
</tr>
<tr>
<td>Total</td>
<td>6418</td>
<td>100</td>
</tr>
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</table>

The choice of rejuvenation method (slash and burn or gap replanting) was largely determined by a household's financial strength (their ability to invest in slashing, burning and replanting). Such financial considerations included family labour availability and the household’s dependency on rubber for a household income. The risks associated with crop failure, damage by vertebrate pests and fluctuation in the market price of rubber, as well as the farmers’ own knowledge and confidence in the gap replanting technique and the availability of land for further clearing, were other driving factors behind the decision to use slash and burn or gap replanting. External factors, such as the availability of government projects and other means of support (capital/credit, land, transport and production inputs) also significantly influenced farmers' decisions and their perception of available options.

Financial calculations have been made, comparing various rubber-based agroforestry systems: the slash-and-burn type (using clonal or seedling plants) and the gap-replanting type. The assumptions made were based...
on farmers planting agricultural crops in the first two years after slash and burn; farmers can therefore also harvest non-rubber products from jungle rubber gardens in addition to latex. Labour for such projects comes primarily from family members. When additional labour is needed, it is hired at Indonesian Rp 7000 and Rp 5000 for a man or woman respectively. Our financial analysis considered two scenarios. In the first scenario, all production factors were purchased and all products were sold. In the second scenario, only some of the production factors were purchased, while most non-rubber products were consumed within the household.

The financial analysis indicated that, in the first scenario and using clonal rubber, return to labour was Rp 15000 while with seedling rubber, this was about Rp 6600. Under the gap replanting scenario, return to labour ranged from Rp 7800 to Rp 9500. All systems indicated their feasibility (Table 2); however, the gap replanting strategy produced a higher net present value (NPV) largely because of its very low input and labour requirements, compared with other systems.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>NPV (20%) (million Rp)</th>
<th>Return to Labour (Rp/ day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slash and burn systems</td>
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<tr>
<td>Clonal rubber (moderate yield)</td>
<td>2.85</td>
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<tr>
<td>Seedling (yield: 0.5 x clonal rubber)</td>
<td>1.83</td>
<td>6176</td>
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<tr>
<td>Sisipan</td>
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<tr>
<td>Seedling (constant yield: 728 kg/ha/ y)</td>
<td>11.16</td>
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<tr>
<td>Seedling (yield: 0.5 x clonal rubber)</td>
<td>11.14</td>
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</tr>
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</table>

Table 2. Feasibility indicators of various rubber based agroforestry systems, in which a proportion of the production inputs were not purchased and some of the non-rubber products were marketed.

In the current context of the increasing labour wage rate in plantations (Rp 10000) and the increasing price of input material (due to inflation), the low and fluctuating price of latex in the market (Figure 7) makes rubber tapping less profitable in comparison with working as a paid labourer in plantations. This is a choice many rubber farmers in Jambi are currently facing.

6.3 Improving rubber agroforestry systems

Jungle rubber agroforestry comprises Hevea brasiliensis as an introduced component within a crop-fallow system. Rubber latex is now the primary product from the system. Agricultural crops have diminished in value in comparison with latex. The jungle rubber agroforestry system is a low-input, low cost, extensive system. However, one of its failings, from a production perspective, is its low latex productivity in comparison with monoculture plantations. Research initiatives by ICRAF and its partner institutions have been undertaken to explore alternatives to enhance the production of rubber latex and other cash crops without a large investment. For several years previously, a series of participatory, on-farm trials were carried out in Jambi, West Sumatra and West Kalimantan Provinces. With the farmers’ participation, different Rubber Agroforestry Systems (RAS) were developed and tested in these regions (Penot and Wibawa, 1997). The following systems offer much potential to increase the production and productivity of jungle rubber agroforestry systems.

6.3.1 RAS 1

Under RAS 1, high yielding rubber clones are used instead of unselected rubber planting material (Boutin et al., 2000). Weeding is limited to 2 m-wide strips along the length of the rubber tree rows (1 m on either side of each tree). Strips between the rubber tree rows are left unweeded, allowing natural vegetation to re-establish (Figure 24). This significantly reduces the labour requirement for weeding and also allows the maintenance of natural vegetation in the inter-rows (Wibawa et al., 2000a).